Microfluidic fuel processors promise miniature power sources

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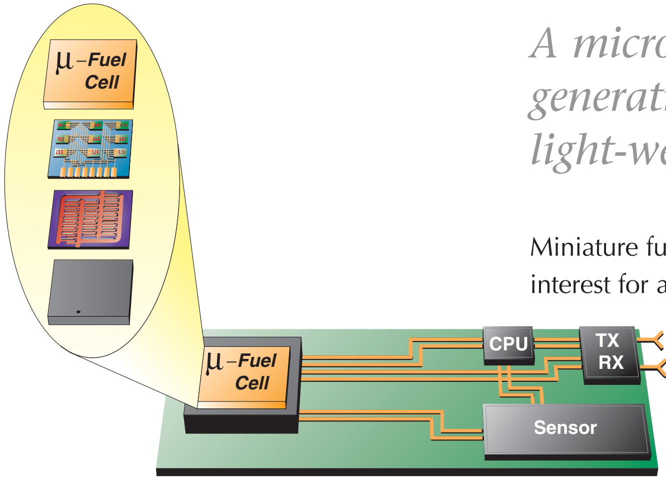
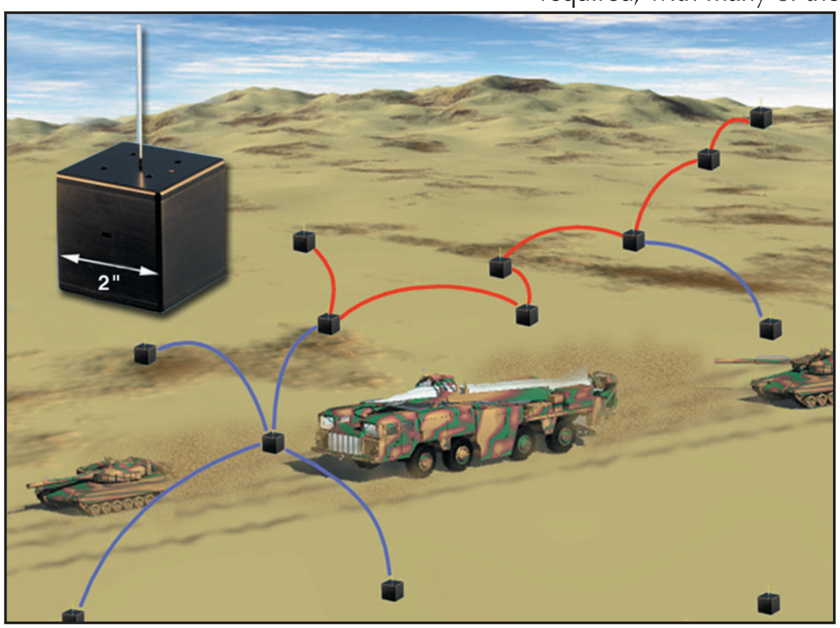
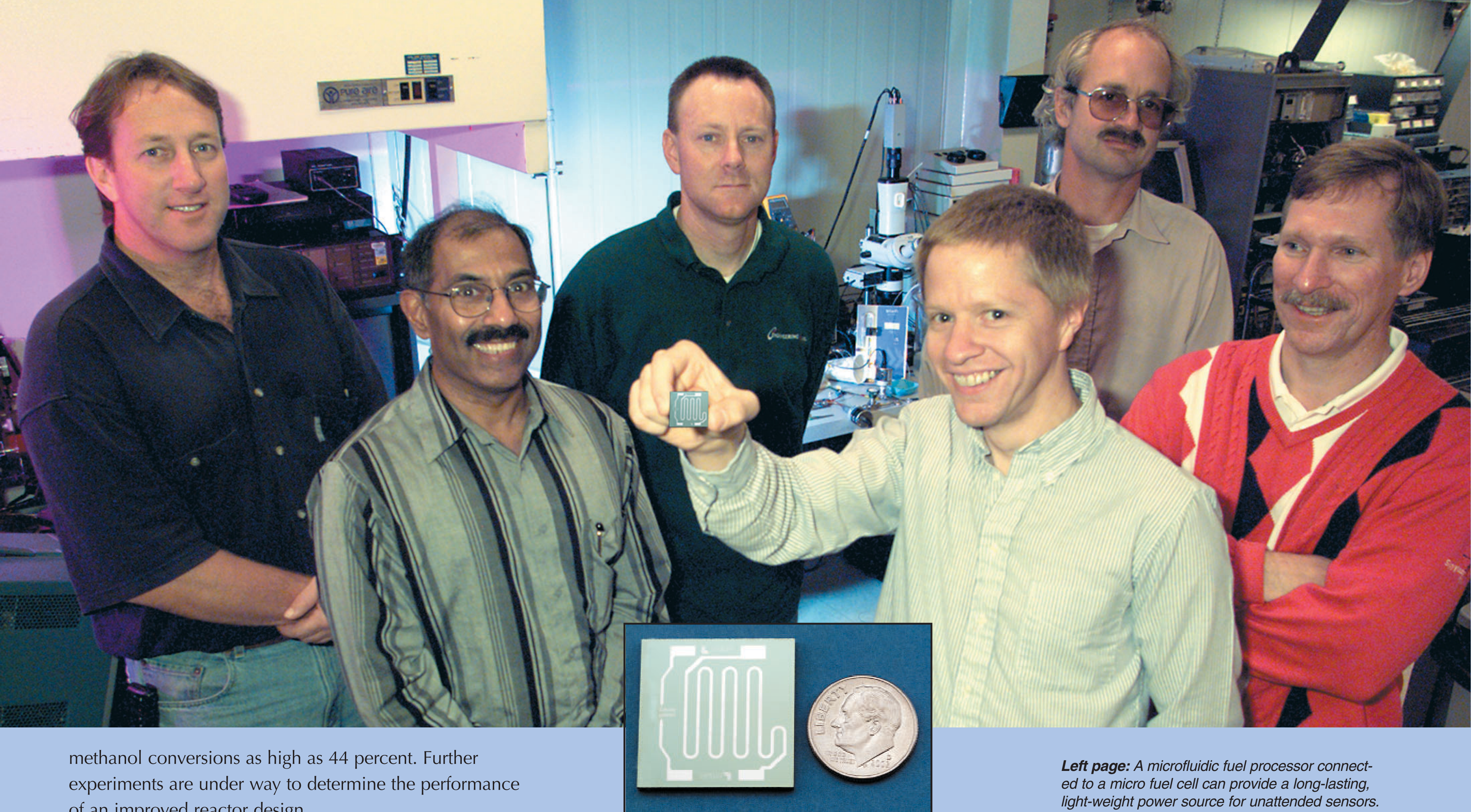


Miniature fuel cells have recently experienced renewed interest for applications in portable power generation. Portable power sources remain critical for all aspects of the military, weapons testing, and intelligence communities. While batteries have become a minor hindrance in the case of consumer portable electronics, they are simply not adequate for the advanced applications of remote reconnaissance, intelligence gathering, and telemetry. New power sources are required, with many of these having specific performance criteria for the direct application. A lighter-weight, longer-lasting power source provides new functionality to missions of all kinds, promising long-term cost benefits to all government agencies while enabling new levels of safety and security for personnel in the field.



Fuel cells store energy as fuel rather than as an integrated part of the structure of the device, as is the case with batteries. Current proton exchange membrane (PEM) fuel cells are limited to 3–15 percent methanol solution, thereby limiting their power and energy density. Our approach is to reform the methanol in a separate microreactor, convert it to hydrogen, and feed the hydrogen to the fuel cell. This approach allows us to exploit the very high energy densities of liquid fuels, using 50 percent methanol-water mixtures; higher concentrations may be possible by using novel water recovery designs. A microfluidic device technology enabling generic hydrogen generation will significantly extend the operating time of virtually any portable fuel cell power source, but most importantly, will lend itself to miniaturization for extremely compact, light-weight systems.

Our goal has been to design, fabricate, and test a microfluidic fuel processor for hydrogen generation for portable fuel cell power sources in order to reform hydrocarbon-based fuels having high specific energy content. With the hydrogen generation of the microfluidic fuel reformer, an integrated power solution targeting the 0.5–20-watt range may be realized. We have made significant advances by successfully depositing sputter-coated nickel and copper-oxide catalysts onto a reactor's microchannels and nanoporous membranes. Experiments performed using different flow patterns have yielded



methanol conversions as high as 44 percent. Further experiments are under way to determine the performance of an improved reactor design.

In the future, continuing efforts will result in a thermally integrated microdevice comprising a microreformer converting methanol to hydrogen, and a fuel cell delivering 500 milliwatts of power output.

Left page: *A microfluidic fuel processor connected to a micro fuel cell can provide a long-lasting, light-weight power source for unattended sensors.*

Right page: *Fuel processor development team members (left to right): Jeff Morse, Ravi Upadhye, Tim Graff, Dave Sopclak, Mark Havstad, and Alan Jankowski.*

Right page, inset: *A fuel cell microreactor is pictured next to a dime to show scale.*